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(54) PRODUCTION OF SILICON SINGLE CRYSTAL AND SEED CRYSTAL

(57)Abstract:
PROBLEM TO BE SOLVED: To extremely simply pull up a silicon single crystal having a large weight without necking the single crystal and without using a complicated device such as a crystal-holding mechanism.
SOLUTION: This method for producing a silicon single crystal comprises a Czochralski method comprising bringing a seed crystal into contact with a melted silicon liquid, rotating the seed crystal and simultaneously slowly pulling up the single crystal to grow the silicon single crystal. The improvement in the method comprises using the seed crystal whose tip to be brought into contact with the silicon melted liquid has a sharpened shape or a sharpened tip-removed shape, slowly bringing the tip of the seed crystal into contact with the silicon melted liquid, lowering the seed crystal at a low speed to melt the tip of the seed crystal until to give a desired thickness, and subsequently slowly pulling up the seed crystal to grow the silicon single crystal bar having a desired diameter without necking the single crystal.

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CLAIMS

[Claim(s)]
[Claim 1] By pulling up slowly, rotating this, after contacting seed crystal to silicon melt In the manufacture approach of the silicon single crystal by the Czochrlski method into which a silicon single crystal rod is grown up The seed crystal which is the configuration where the configuration of a point of making the silicon melt of this seed crystal contacting cut off the configuration where it sharpened, or the sharp tip is used. It fuses until the point of seed crystal serves as a desired size by dropping this seed crystal with a low speed, after contacting the tip of this seed crystal to silicon melt calmly first. Then, the manufacture approach of the silicon single crystal characterized by what is made to raise the silicon single crystal rod of the diameter of a request, without necking by raising this seed crystal slowly.
[Claim 2] The manufacture approach of the silicon single crystal according to claim 1 characterized by what this seed crystal is kept warm for by holding seed crystal right above [silicon melt] before contacting the tip of said seed crystal to silicon melt calmly.
[Claim 3] The manufacture approach of the silicon single crystal according to claim 1 or 2 characterized by making into 20 or less mm/min the rate which descends said seed crystal with a low speed, and fuses a point.
[Claim 4] Silicon seed crystal used in case a silicon single crystal rod is manufactured with the Czochrlski method characterized by being the configuration where the configuration of a point of making silicon melt contacting cut off the configuration where it sharpened, or the sharp tip.
[Claim 5] Silicon seed crystal according to claim 4 with which the configuration of said point is characterized by being a cone or a pyramid configuration.
[Claim 6] Silicon seed crystal according to claim 4 or 5 with which area of the field which contacts silicon melt to the beginning at the tip of seed crystal is characterized by being below 9pi (mm2).
[Claim 7] Silicon seed crystal given in any 1 term of claim 4 to which area of the field which contacts silicon melt to the beginning at the tip of seed crystal is characterized by being below 2.25pi (mm2) thru/or claim 6.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the approach of manufacturing a silicon single crystal, in the manufacture approach of the silicon single crystal by the Czochrlski method (Czochralski Method= CZ process), without performing the so-called seed diaphragm (necking). Furthermore, this invention relates also to the configuration of the seed crystal used in this approach.
[0002]
[Description of the Prior Art] Conventionally, after contacting this to silicon melt in manufacture of the silicon single crystal by the Czochrlski method, using single crystal silicon as seed crystal, a single crystal rod is grown up by pulling up slowly, making it rotate. Under the present circumstances, when contacting seed crystal to silicon melt, in order to extinguish the rearrangement generated in high density in seed crystal by the thermal shock, a seed diaphragm (necking) is performed, subsequently to desired aperture, a crystal is fattened until it becomes and the silicon single crystal is pulled up. such a seed diaphragm -- DashNecking -- it is widely known as law and considers as the common sense in the case of pulling up a silicon single crystal rod with the Czochrlski method.
[0003] That is, as the configuration of the seed crystal used conventionally is shown in drawing 3 (A) and (B), the notching section for setting to a seed electrode holder should be put into a diameter or the one side of the shape of an about 8-20mm cylinder, or a prismatic form thing, and the tip configuration of the lower part which will contact silicon melt first serves as a flat side. And in order to bear the weight of the single crystal rod of the amount of Takashige and to pull up safely, it is difficult for the size of seed crystal to make it thin below at the above.
[0004] Since the heat capacity at the tip in contact with melt is large, seed crystal produces a temperature gradient rapid in a crystal at the moment of contacting melt, and high density is made to generate a slip rearrangement in the seed crystal of such a configuration. Therefore, said necking is needed, in order to eliminate this rearrangement and to raise a single crystal.
[0005] This Dash After the Necking method contacts seed crystal to silicon melt, it makes a diameter once thin at about 3mm, forms a converging section, extinguishes the rearrangement spread from the slip rearrangement introduced into seed crystal, and obtains the single crystal of a non-rearrangement.
[0006] However, even if it chooses various necking conditions, in order to form a-less rearrangement by such approach, the minimum diameter of 5-6mm needed to narrow down, reinforcement was not enough to support the single crystal rod formed into Shigekazu Taka with increase of the diameter of a silicon single crystal in recent years, this thin converging section fractured during crystal rod raising, and there was a possibility of producing the serious accident of a single crystal rod falling.
[0007] Then, in raising of a large diameter in recent years and the amount crystal rod of Takashige, development of the approach using a crystal maintenance device is furthered (for example, refer to JP,5-65477,B). As mentioned above, since necking is indispensable because of rearrangement[non-]-izing and this approach cannot strengthen reinforcement of a seed converging section, it holds a growth crystal rod directly mechanically instead.

[0008] However, since such an approach is what holds directly the single crystal rod which grows slowly, rotating at an elevated temperature, equipment will become complicated and expensive and it also produces a heat-resistant problem. It is very difficult to hold moreover, without actually giving vibration etc. to a growth crystal, and since a growth crystal will be made to polycrystal-ize or the equipment which is right above [further hot / silicon melt] complicated, and has devices, such as rotation and sliding, will be arranged, there are various problems of polluting a crystal with a heavy-metal impurity.
[0009] In order to solve such a problem, these people proposed JP,5-139880,A and invention like Japanese Patent Application No. No. 87187 [eight to] previously. It excels, and by [whose slip rearrangement which enters when the configuration of the point of seed crystal is made into the configuration which has a wedge shape or a centrum and seed crystal contacts silicon melt is made] decreasing, even if this invention makes the diameter of a converging section comparatively thick, non-rearrangement-ization is enabled, and it has it and raises the reinforcement of a converging section.
[0010] since the size of a converging section can be made thick by this approach, also although kicked, it necks, and it may be unchanging for forming the converging section with a slip rearrangement whose improvement in the reinforcement of a converging section can be performed to some extent, reinforcement may become inadequate for raising of a large diameter and the single crystal rod which long-picture-izes, for example, amounts to 150kg or more recent years increasingly, and it has not resulted in fundamental solution.
[0011]
[Problem(s) to be Solved by the Invention] Then, this invention is what was made in view of the above conventional problems. Without forming the converging section by necking which poses the first problem on reinforcement A crystal can be made to single-crystal-ize. A large diameter and Shigekazu Taka's long picture silicon single crystal It aims at offering the silicon seed crystal used for the manufacture approach of a silicon single crystal and this which can be pulled up very easily, without using complicated equipment like a crystal maintenance device.
[0012]
[Means for Solving the Problem] In order to solve the above-mentioned technical problem, invention indicated to claim 1 of this invention By pulling up slowly, rotating this, after contacting seed crystal to silicon melt In the manufacture approach of the silicon single crystal by the Czochrlski method into which a silicon single crystal rod is grown up The seed crystal which is the configuration where the configuration of a point of making the silicon melt of this seed crystal contacting cut off the configuration where it sharpened, or the sharp tip is used. It fuses until the point of seed crystal serves as a desired size by dropping this seed crystal with a low speed, after contacting the tip of this seed crystal to silicon melt calmly first. Then, it is the manufacture approach of the silicon single crystal characterized by what is made to raise the silicon single crystal rod of the diameter of a request, without necking by raising this seed crystal slowly.
[0013] Thus, when the configuration of a point used the seed crystal which is the configuration which cut off the configuration where it sharpened, or the sharp tip and the tip of seed crystal is first contacted to silicon melt, the touch area to melt is small, and since the heat capacity of a point is small and a thermal shock or a rapid temperature gradient is not formed in seed crystal, a slip rearrangement is not introduced. And if it fuses until it drops seed crystal with a low speed after that and the point of seed crystal serves as a desired size, since seed crystal can be fused to a request size, without forming a rapid temperature gradient in seed crystal, a slip rearrangement is not introduced in seed crystal at the time of melting.
[0014] And it is not necessary to neck, and since reinforcement is also enough, it can be made to be able to grow fat to the diameter of a request as it is, and a silicon single crystal rod can be made to raise finally, since seed crystal will be a request size as mentioned above and it will be a non-rearrangement, if seed crystal is raised slowly, controlling temperature, a raising rate, etc.
[0015] In this case, as indicated to claim 2, before contacting the tip of seed crystal to silicon melt calmly, it is desirable by holding seed crystal right above [silicon melt] to keep seed crystal warm.

[0016] Thus, it is because the thermal shock at the time of contact will soften and prevention of installation of a slip rearrangement will be more certainly aimed at, if it is made to make silicon melt contact after keeping seed crystal warm. When it considers as the configuration which cut off the tip which sharpened the configuration of the seed crystal used especially, the need for incubation is high.
[0017] Moreover, as indicated to claim 3, as for the rate which descends seed crystal with a low speed and fuses a point, considering as 20 or less mm/min is desirable. Thus, risk of a slip rearrangement being introduced in seed crystal at the time of melting can be reduced more by fusing slowly.
[0018] Next, invention indicated to claim 4 of this invention is silicon seed crystal used in case a silicon single crystal rod is manufactured with the Czochrlski method characterized by being the configuration where the configuration of a point of making silicon melt contacting cut off the configuration where it sharpened, or the sharp tip.
[0019] Thus, since a touch area is small and the heat capacity of a point is small when contacting seed crystal to silicon melt if the configuration of a point is the seed crystal which is the configuration which cut off the configuration where it sharpened, or the sharp tip, the slip rearrangement by the thermal shock or the rapid temperature gradient is not introduced into seed crystal.
[0020] And if it fuses until it drops seed crystal slowly after that and a point serves as a desired size, since the touch area of the seed crystal in melt and melt increases gradually, a rapid temperature gradient will not be formed in seed crystal, and a slip rearrangement will not be introduced in seed crystal at the time of melting.
[0021] And in this case, like claim 5, since it is a symmetrical configuration while a cone or a pyramid configuration, then processing are easy, a temperature gradient will also tend to become uniform and a slip rearrangement cannot enter the configuration of the point of seed crystal easily, either.
[0022] Moreover, the area of the field which contacts silicon melt to the beginning at the tip of seed crystal is good like claim 6 and claim 7 for carrying out to below 9pi (mm2) to carry out to below 2.25pi (mm2) at best still more preferably.
[0023] Thus, it is because heat capacity is small, so the thermal shock at the time of contact can be made small if area of the field first contacted to melt is made small. Therefore, it is most desirable to consider as the configuration which made the touch area small infinite where it sharpened completely.
[0024]
[Embodiment of the Invention] Hereafter, although the gestalt of operation of this invention is explained, this invention is not limited to these. Without having a question in the common sense in the Czochrlski method that a single crystal cannot be pulled up if the seed crystal of a single crystal is contacted to silicon melt, and a slip rearrangement will occur and it will not neck after that, and making seed crystal generate a slip rearrangement, this invention persons could not make melt contact, or added various examination.
[0025] And if melt can be made to contact, without making seed crystal generate a slip rearrangement, it is not necessary to neck primarily and to make a converging section able to form, it can be made to be able to grow fat to the diameter of a request as it is, and a silicon single crystal rod can be made to grow. And if such a thing can be performed, the path of the conventional converging section should be able to solve fundamentally various problems of **, such as a problem of the lack of on the strength by existence of a small thing and a slip rearrangement etc., and the crystal supporting structure.
[0026] Although a part of tip will dissolve, seed crystal and silicon melt will paste up and it will become raisable [a subsequent crystal] if seed crystal contacts this point and melt, there is an interesting phenomenon this invention persons are doing [a phenomenon / the single crystal] knowledge to silicon melt about contact or the rearrangement when separating or fusing in this way.
[0027] For example, although it is known that a slip rearrangement will be introduced also into the part which generally already grew as a single crystal in accordance with a temperature gradient by the Czochrlski method when a crystal rod is intentionally separated from silicon melt while raising the silicon single crystal rod, the consistency of the slip rearrangement introduced and a field are influenced by the temperature gradient in a growth crystal. If the growth rate of a single crystal rod is made into a high speed and a temperature gradient is enlarged, the consistency of a slip rearrangement and a field

will become large, but a reverse result will be brought, if a growth rate is made into a low speed and a temperature gradient is made small. When the crystal rod especially grown up by super-low ** is separated, a slip rearrangement may hardly enter. From this, it is thought possible to separate the single crystal in contact with silicon melt from silicon melt, without introducing a slip rearrangement.

[0028] Moreover, although the melting zone of silicon is formed and a single crystal rod is grown up in the so-called FZ method (Floating Zone law), it can perform simply raising heater power during training of this single crystal rod, and lengthening the width of face of a melting zone. Although the single crystal part in contact with silicon melt which already grew will fuse again at this time, a rearrangement is hardly introduced owing to this. It is thought possible to fuse some single crystals in contact with silicon melt from this, without introducing a slip rearrangement in a single crystal.

[0029] Furthermore, with the Czochrlski method, while growing up a silicon single crystal rod, it is fixed within the limits about a growth rate by adjusting temperature etc., and can change free. Although it is known that the growth interface configuration (solid-liquid interface configuration) of a single crystal rod will change if a growth rate is changed during single crystal growth, by the solid-liquid interface, remelting of a single crystal part which already grew happens at this time. Raising can be continued without introducing a rearrangement into a single crystal rod also in this case. It is thought possible to fuse, without introducing a slip rearrangement in a single crystal for some single crystals which contacted silicon melt also from this.

[0030] Putting the above phenomena together, if it separates, or a silicon single crystal does not give a thermal shock or a rapid temperature gradient to silicon melt contact or when fusing, it is considered that a rearrangement will not be introduced.

[0031] Then, the following tests were performed in order to check this.

(Test 1) First, as shown in drawing 1 (A), necking usually performed using the seed crystal 1 of the usual square pole configuration was performed. That is, in order to remove the slip rearrangement 2 introduced when contacting seed crystal 1 to silicon melt, the converging section 3 was formed and the crystal was formed into the-less rearrangement. Then, the crystal was fattened to the diameter of about 10mm, and growth of a single crystal was continued for this diameter. While stopping raising of seed crystal and stopping growth of a single crystal in the place into which the single crystal with a diameter [this] of about 10mm was grown up to die length of about 10cm, seed crystal was conversely dropped slowly at each rate of 3 mm/min, 10 mm/min, and 20 mm/min, and about 2cm of single crystals which already grew was remelted by being immersed in silicon melt. And although growth of the body section 5 was continued succeedingly in the place where it changed to raising of seed crystal again, and the temperature of melt was lowered at, the cone section 4 was formed at, and the diameter became 10cm in the place where remelting of these about 2cm was carried out, growth of the single crystal rod of a non-rearrangement continued.

[0032] This shows that a slip rearrangement does not enter only by saying [having only fused the same single crystal as a size of the almost conventional seed crystal called the diameter of about 10mm from the condition of having contacted silicon melt]. Since this is what fuses the single crystal which already touches silicon melt by being further immersed in melt slowly, it does not require a thermal shock for a single crystal on the occasion of melting, and is considered to be because for the rapid temperature gradient not to be formed in the single crystal.

[0033] (Test 2) Next, it investigated about the possibility of remelting in the non-rearrangement of the single crystal once separated from melt. That is, as shown in drawing 1 (B), necking usually performed using the seed crystal 1 of the usual square pole configuration was performed. In order to remove the slip rearrangement 2 introduced when contacting seed crystal 1 to silicon melt, the converging section 3 was formed and the crystal was formed into the-less rearrangement. Then, the crystal was fattened to the diameter of about 10mm, and growth of a single crystal was continued for this diameter. The tail part 6 of a cone configuration was formed by die length of about 5cm, the single crystal was separated from silicon melt, and crystal growth was terminated for a while in the place into which the single crystal with a diameter [this] of about 10mm was grown up to die length of about 10cm.

[0034] After having once taken out the made small single crystal rod outside the crystal manufacture

furnace while it had been joined to seed crystal through the diaphragm, and cooling to a room temperature, the non-illustrated seed electrode holder was again equipped with seed crystal, and the crystal was returned in the crystal manufacture furnace. And seed crystal was dropped, it stopped for 10 minutes in the location where the crystal tail part 6 is held right above [silicon melt], and the crystal rod was kept warm.

[0035] If incubation was completed, seed crystal was further dropped slowly at each rate of 3 mm/min, 10 mm/min, and 20 mm/min from the location. Then, the tip of the conic tail part 6 contacts silicon melt calmly, and, subsequently melting of the tail part is carried out little by little. Although melting was then continued, and growth of the body section was continued succeedingly in the place where the temperature of melt was lowered as it was at, the cone section 4 was formed at, and the diameter became 10cm, without necking by changing to raising of seed crystal in the place which was immersed in melt and about 2cm fused under the part with a diameter of 10mm, growth of the single crystal rod of a non-rearrangement continued.

[0036] It turns out that it is possible to contact and fuse this from this to silicon melt, without producing a slip rearrangement even if it is the case where a single crystal is once cooled even if. Although single crystals are the contact and melting from the condition of not being in contact with silicon melt, since the area of the part which contacts first is small, heat capacity is small and a touch area becomes large gradually by not giving the thermal shock by the contact to silicon melt to a single crystal, and dropping seed crystal slowly after that, this is considered to be because for a temperature gradient rapid in a single crystal not to be formed during melting.

[0037] (Test 3) Finally the seed crystal which processed mechanically and was produced was remelted by the non-rearrangement, and it investigated about possibility of growing up a single crystal, without necking. That is, the crystal of the shape of a cylinder with a diameter [of 10mm] and a die length of 15cm was first cut down from the single crystal ingot of a non-rearrangement, and as shown in drawing 1 (C), about 5cm of one tips was mechanically processed in the shape of a cone. Subsequently, etching removal of the damage layer of the front face by machining was carried out, and the configurations of the tail part 6 of the small single crystal rod produced by the test 2 and the point mostly made with the silicon single crystal of the same configuration produced the seed crystal 1 which is a cone configuration.

[0038] It carried out to growing up a single crystal rod like the test 2 using this seed crystal. This point equipped the seed electrode holder with the seed crystal of a cone configuration first, subsequently seed crystal was dropped, it stopped for 10 minutes in the location where the cone section is held right above [silicon melt], and seed crystal was kept warm.

[0039] If incubation was completed, seed crystal was further dropped slowly at each rate of 3 mm/min, 10 mm/min, and 20 mm/min from the location. Then, the tip of the cone section contacts silicon melt calmly, and, subsequently melting of the cone section is carried out little by little. Although melting was then continued, and growth of the body section was continued succeedingly in the place where the temperature of melt was lowered as it was at, the cone section 4 was formed at, and the diameter became 20cm, without necking by changing to raising of seed crystal in the place which was immersed in melt and about 2cm fused under the part with a diameter of 10mm, growth of the single crystal rod of a non-rearrangement continued.

[0040] In this way, cut down and processed seed crystal from the big single crystal ingot like the conventional seed crystal, and silicon melt was made to contact, without producing a slip rearrangement in seed crystal, even if it was the case where the seed crystal which carried out etching removal of the surface processing damage was used, it turned out that it is possible to fuse until it becomes a desired size, making a touch area increase slowly subsequently, and this invention was completed.

[0041] Although this is the case where seed crystal contacts and fuses from the condition of not being in contact with silicon melt, as mentioned above at silicon melt Since the area of the part which contacts first is small, heat capacity is small and a touch area becomes large gradually by not giving the thermal shock by the contact to silicon melt to seed crystal, and dropping seed crystal slowly after that, It is because a temperature gradient rapid in seed crystal is not formed during melting.

[0042] Therefore, it sets to manufacture of the silicon single crystal rod by the Czochrlski method. The configuration of a point of making the silicon melt of seed crystal contacting uses the seed crystal which is the configuration which cut off the small configuration where it sharpened or the sharp tip of a touch area. It fuses until the point of seed crystal serves as a size of the request which can bear the weight of a subsequent Shigekazu Taka single crystal rod by contacting the tip of this seed crystal to silicon melt calmly, and dropping this seed crystal slowly with a low speed after that. Subsequently A silicon single crystal rod can be made to raise, if seed crystal is raised slowly and a single crystal is fattened to the diameter of a request as it is, without necking.

[0043] If it is in such this invention, it is necessary to consider as the configuration which cut off the configuration where the configuration of the point of the seed crystal to be used was sharpened, or the sharp tip. When it was such a configuration and the tip of seed crystal contacts silicon melt first, the touch area to melt is small, and it is because a thermal shock or a rapid temperature gradient is not formed in seed crystal since the heat capacity of a point is small, so a slip rearrangement is not introduced.

[0044] And if it fuses until it drops seed crystal slowly after that and the point of seed crystal serves as a desired size, since the touch area of the seed crystal in melt and melt increases gradually, seed crystal can be fused without forming a rapid temperature gradient in seed crystal, and a slip rearrangement will not be introduced in seed crystal at the time of melting.

[0045] As a configuration of the seed crystal point of the configuration which cut off the sharp configuration or the sharp tip used by such this invention, considering as a cone or a pyramid configuration is desirable. The heat capacity at a tip is small, with such a configuration, since it is the configuration which becomes thick after that gradually, while suiting very well the conditions searched for by this invention, processing is easy, and it is because it is a symmetrical configuration, so a temperature gradient will also tend to become uniform and a slip rearrangement cannot enter easily, either.

[0046] In this case, although die-length t of the cone section 7 of the seed crystal concerning this invention shown in drawing 2 and the pyramid section 8 is arbitrary and it can determine suitably for convenience' sake on processing, since the rate of increase of a touch area with melt will become large if it shortens not much, it is necessary to make a melting rate small. on the contrary -- since it is useless if it lengthens not much -- this die-length t -- about 1 to 10 times of the size of seed crystal -- more -- desirable -- two to 8 times -- then, it is good.

[0047] Moreover, since the seed crystal of this invention should just be the configuration which the tip is sharp and becomes thick after that gradually, its pyramid configuration is also good also as a triangular pyramid, a square drill, or a multiple drill beyond it. Moreover, it is not necessary to make in agreement the cross-section configuration of the body section of seed crystal, and the cross-section configuration of a point, and it is good also as what processed the point of the seed crystal of a prism configuration on the cone, and a configuration can be combined with arbitration for convenience' sake.

[0048] Moreover, it is difficult for the thing as which the configuration which cut off the sharp tip not only like the configuration where the tip configuration of seed crystal as shown in drawing 2 (A) and (B) sharpened but like drawing 2 (C) is sufficient on processing of a weak hard silicon single crystal for it to be radicalized in a tip in remainder, and it is because a thermal shock can be prevented if the problem on the handling of breakage etc. arises and also it is below a fixed area. And how to cut off a tip is also arbitrary, when cutting off horizontally, it is not restricted, for example, you may cut off aslant like drawing 2 (D).

[0049] And the area of the field which contacts silicon melt to the beginning at the tip of seed crystal when a tip is cut off, for example is good for carrying out to below 9pi (mm2) to carry out to below 2.25pi (mm2) at best still more preferably.

[0050] Since it is referred to as 3mm or less in order to set the diameter of the converging section in the case of making this form into a-less rearrangement by the conventional necking in this invention persons' experimental research to 6mm or less and to make a-less rearrangement form certainly, if it does not carry out to below this cross section, it is because a slip rearrangement tends to enter at the time

of contact. Therefore, when contacting seed crystal to melt, in order not to generate a slip rearrangement, it is most desirable to consider as the configuration which made the touch area small infinite where it sharpened completely (drawing 2 (A), (B)).
[0051] Next, before contacting the tip of the seed crystal of the above-mentioned configuration to silicon melt calmly in this invention, it is desirable by holding seed crystal right above [silicon melt] to keep seed crystal warm. This is because the thermal shock at the time of contact will soften and prevention of installation of a slip rearrangement will be more certainly aimed at, if it is made to make silicon melt contact after keeping seed crystal warm. When it considers as the configuration which cut off the tip which sharpened the configuration of the seed crystal used especially, the need for incubation is high.
[0052] And although it cannot be overemphasized that it is more desirable to carry out for a long time in the location more near melt, the tip of seed crystal should just make the maintenance location of this seed crystal, and the holding time from melt 5-100mm and about 1 - 20 minutes, for example.
[0053] Moreover, as for the rate which descends slowly with a low speed and fuses a point, in this invention, considering as 20 or less mm/min is [after contacting melt in seed crystal] desirable. Thus, it is because risk of a slip rearrangement being introduced in seed crystal at the time of melting can be reduced more by fusing slowly. Therefore, this rate is influenced with the configuration of the rate of increase of the melt touch area of the point of seed crystal, i.e., the point of seed crystal, and the more acutance of image is large, the more a melting rate can also enlarge it.
[0054] And what is necessary is just to consider, for example as the size of 8mm or more as a size of this request, although the point of seed crystal is fused to the size of the request which can support the weight of the single crystal rod of the amount of Takashige. since a single crystal rod can be succeedingly grown up from seed crystal and a slip rearrangement does not exist in this part in this invention, as compared with the converging section with which the same size also has the conventional rearrangement, it is markedly alike and reinforcement is high. Since it can be made to be able to grow fat to the diameter of a request and a silicon single crystal rod can be made to raise, without moreover necking as it is from seed crystal, the time amount which necking which needs to be performed 20cm or more conventionally takes, for example can be saved.
[0055] If melting is completed to the size of a request of the point of seed crystal at the last, seed crystal is raised slowly, like the usual Czochrlski method, if the cone section is formed and it becomes a diameter of a request, controlling temperature, a raising rate, etc., the body section can be formed, and the silicon single crystal rod of the amount of Takashige can be pulled up safely at it.
[0056] And the diameter of the silicon single crystal called for in recent years is formed into a large diameter to 8 inches (200mm) - 12 inches (300mm) 16 more inches (400mm). However, in this invention, without using the crystal supporting structure etc., if it is below the threshold value as physical properties of the silicon single crystal itself since it does not neck and a slip rearrangement does not exist, either, even if it is the single crystal rod of what kind of diameter, die length, and weight in principle, it can pull up.
[0057] In addition, this invention is not limited to the above-mentioned operation gestalt. The above-mentioned operation gestalt is instantiation, and no matter it may be what thing which has the same configuration substantially with the technical thought indicated by the claim of this invention, and does the same operation effectiveness so, it is included by the technical range of this invention.
[0058] for example, MCZ to which this invention impresses a magnetic field at the time of a pull-up of not only the usual Czochrlski method but a silicon single crystal -- not only the Czochrlski method usual to vocabulary called the Czochrlski method which was used by this detail letter to say nothing of being applicable also like law (Magnetic field applied Czochralski crystal growth method) but MCZ -- law is also included.
[0059]
[Effect of the Invention] A crystal can be made to single-crystal-ize, without according to this invention, forming the seed converging section by necking which poses the first problem on reinforcement, in case a silicon single crystal rod is pulled up with the conventional Czochrlski method, and a large diameter and Shigekazu Taka's long picture silicon single crystal can be pulled up very easily, without using

complicated equipment like a crystal maintenance device. Consequently, while being able to pull up 8 inches - 12 inches called for in recent years or the silicon single crystal rod beyond it without the risk of fall of the silicon single crystal rod to pull up by the desired die length, necking time amount becomes unnecessary, productive efficiency increases, and there is also an equipment-advantage of being able to save the part from which a long diaphragm becomes unnecessary, and the stroke which carries out perpendicular ** of the seed crystal. Therefore, the productivity of the silicon single crystal of the future diameter of macrostomia, the yield, and cost are remarkably improvable.

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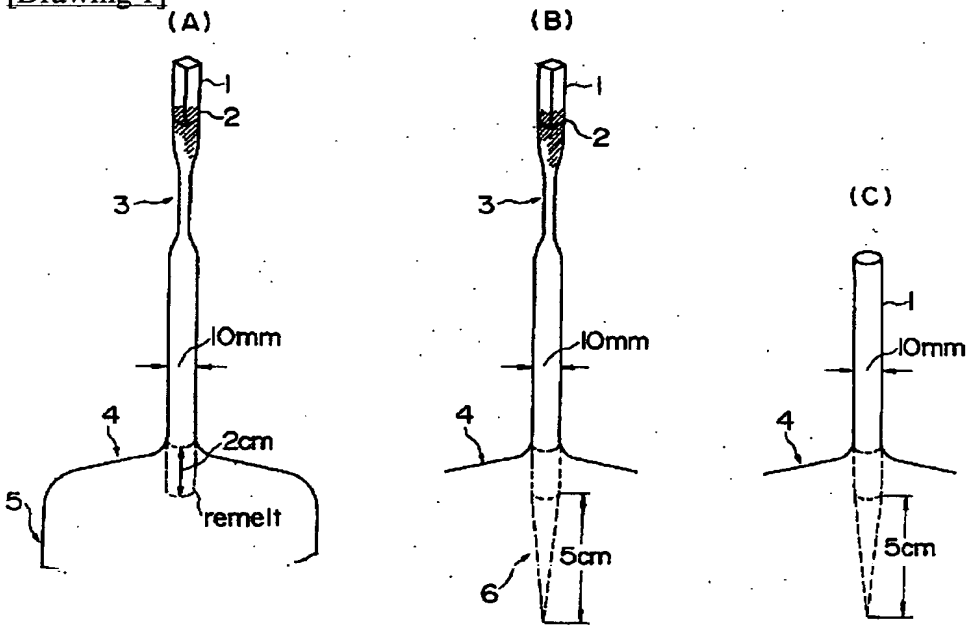
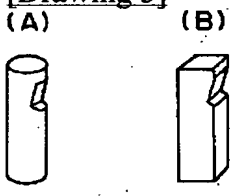
DRAWINGS

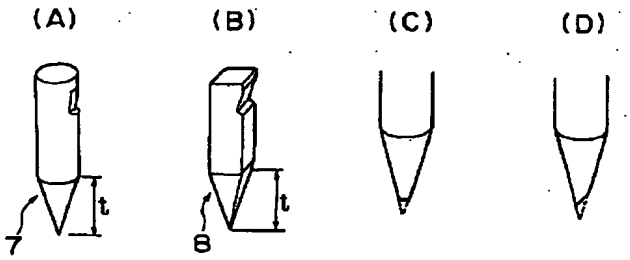
[Drawing 1]



[Drawing 3]



[Drawing 2]



[Translation done.]